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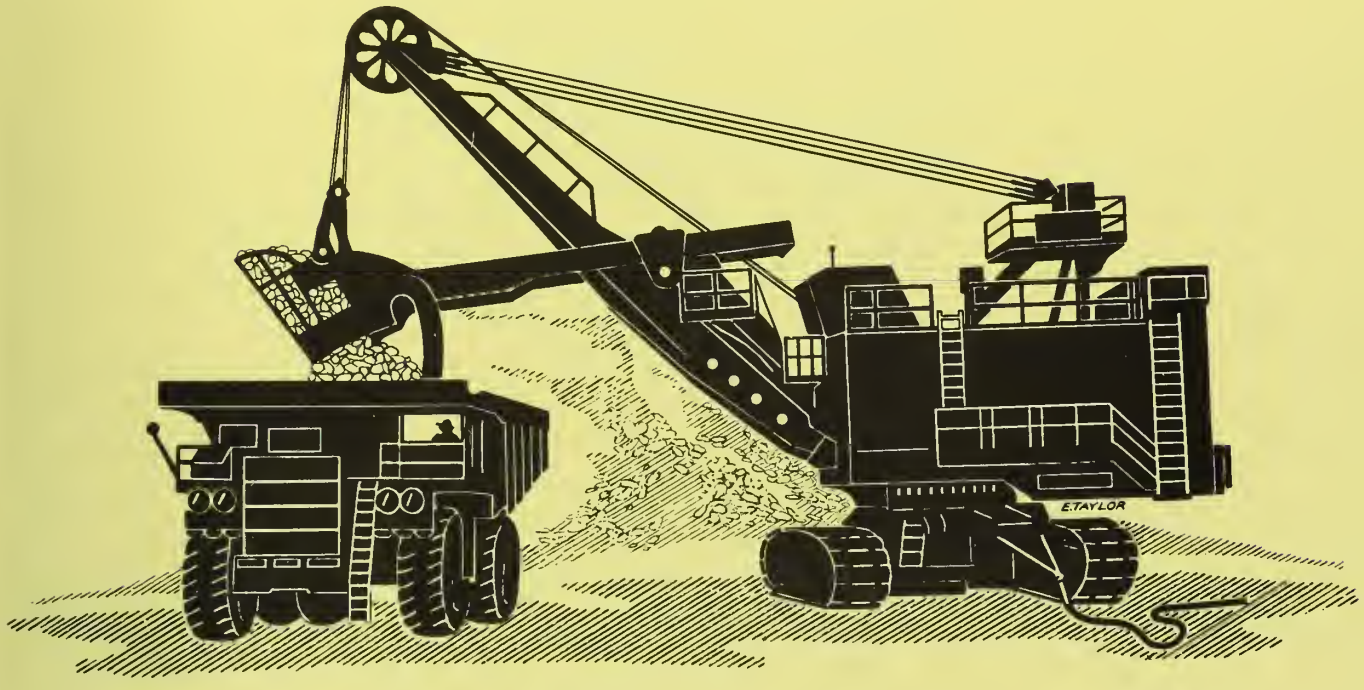
MINERAL COMMODITY REPORT

—— BARITE ——

1985



CALIFORNIA DEPARTMENT OF CONSERVATION
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SPECIAL PUBLICATION 76

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SPECIAL PUBLICATION 76

MINERAL COMMODITY REPORT

—— BARITE ——

1985

By
MICHAEL A. SILVA

Part I from
the U.S. Bureau of Mines publication,
Mineral Commodity Summaries, 1984

CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY
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INTRODUCTION

This report on the availability and demand for barite in California, the United States, and the world is one in a series of Mineral Commodity Reports prepared by the Department of Conservation, Division of Mines and Geology (DMG) to describe commodities of significance to California and the nation.

This mineral commodity report was compiled by Michael A. Silva of the DMG geologic staff. Part I consists of United States and world-wide mineral statistic information and economic analysis adopted directly from the U.S. Bureau of Mines "Mineral Commodity Summaries, 1984." Part II discusses production of the commodity in California. The U.S. Bureau of Mines presents the earliest Government estimates of non-fuel mineral-industry data, including world resource data provided by the U.S. Geological Survey.

Barite, also known as barytes, heavy spar, tiff and cawk, is the mineralogical name for the sulfate of barium ($BaSO_4$) and is derived from the Greek word "barys" meaning heavy. This soft, heavy, and chemically inert mineral is used as a major component of well drilling mud. Over 90 percent of barite produced in the world is ground for use in weighted muds for oil and gas well drilling. The remaining is used as a filler in rubber, paint, plastic, paper, and glass, and is used for the manufacture of barium chemicals (Morse, 1980). Witherite ($BaCO_3$) is much less common than barite, but has been used as a drilling mud component and as a source for barium chemicals. Barium is more easily recovered from witherite and sanbornite ($BaSi_2O_5$). Sanbornite has never been mined commercially, but remains a potential source for barium chemical production (Braun, 1950; Matthews and Alfors, 1962).

Commerical deposits of barite occur worldwide as (1) residual deposits derived from the weathering of barite-bearing rocks, (2) dark, bedded deposits associated with limestone, dolomite, and shale, and (3) vein and cavity-filling deposits precipitated from low-temperature hydrothermal solutions. Bedded deposits account for approximately 85 percent of domestic barite production. In California, all recent production has been from bedded deposits (Brobst, 1975; Papke, 1983).

In 1983, approximately 65 percent of the 2,000,000 tons of barite utilized in the United States was imported from foreign sources, principally China (29%), Peru (17%), Chile (12%), Morocco (12%), and others (30%). United States production was 700,000 tons, only one-fourth (25%) the volume mined just two years earlier, and comparable with 1973-1974 output. There was no recorded production of barite in California for 1983.

For further information, please call (916) 445-5716, the DMG centralized information number.

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PART I: UNITED STATES AND WORLDWIDE
(Data in thousand short tons, unless noted)

1. UNITED STATES PRODUCTION AND USE

Barite: Barite production in 1983 declined for the second consecutive year from the 1981 record high of 2.8 million tons valued at $102 million to 0.7 million tons valued at $27 million. Production came from six states, with 90 percent of the total from Nevada. Other leading states were Georgia and Missouri. About 2.5 million tons of ground barite from domestic production and imports was sold in 1983. Over 90 percent of the barite produced was used as a weighting agent in oil and gas well drilling fluids. Barite was also used in paints, glass, and rubber, and for producing barium chemicals.

2. SALIENT STATISTICS -- UNITED STATES

	1979	1980	1981	1982	1983e
Production: Mine[1]	2,112	2,245	2,849	1,845	700
Imports for consumption (crude barite)	1,489	1,850	1,932	2,320	1,300
Exports	109	97	62	49	14
Apparent consumption (crude barite)	3,492	3,998	4,719	4,116	2,000
Consumption[2] (ground and crushed)	3,223	3,649	4,716	4,088	2,500
Price (average annual): dollars per ton, mine	25.46	29.38	35.96	37.68	37.00
Stocks: Producer, yearend		Not Available			
Employment: Mine and Mille	1,800	2,050	2,150	1,500	1,000
Net import reliance[3] as a percent of apparent consumption	40	44	40	55	64

---

e Estimated.
1 Sold or used by producers.
2 Domestic and imported crude barite sold or used by grinding establishments.
3 Net import reliance = exports + adjustments for Government and industry stock changes.

Prepared by S.G. Ampian, telephone number (202) 634-1180.

3. RECYCLING

None.

4. IMPORT SOURCES (1979-82)

China 29%, Peru 17%, Chile and Morocco 12% each, Other 30%.

5. TARIFF

	Number	Most Favored Nation (MFN)		Non-MFN
		1/1/84	1/1/87	1/1/84
Crude barite	472.10	$1.27/long ton	$1.27/long ton	$4.00/long ton
Ground barite	472.12	$3.25/long ton	$3.25/long ton	$7.50/long ton
Blanc fixe	472.14	0.2¢/lb.	0.2¢/lb	1.25¢/lb.

6. DEPLETION ALLOWANCES

14% (Domestic), 14% (Foreign).

7. GOVERNMENT STOCKPILE

None.

8. EVENTS, TRENDS, AND ISSUES

Demand for barite in 1983 continued its sharp decline which began in the latter half of 1982, from the record highs of recent years, owing to the persistent oil glut and economic downturn which resulted in lower oil and gas well drilling activity. In 1983, primary producers of barite lowered output to pre-1975 levels and imports for consumption of cheaper foreign crude barite declined from its high in 1982 to 1978 levels. Barite grinding capacity, which escalated earlier to meet the higher demand, was in a position to meet present and/or projected demand. From a 1982 base, barite demand is expected to increase at an average annual rate of 4 percent through 1990; however, barite demand in the shorter term, from 1983 to 1985, is expected to increase at an annual rate of less than 4 percent. It is estimated that in 1984 domestic mine production will be at 1.0 million tons and U.S. apparent consumption will be 2.2 million tons.

The low cost and technical advantages of barite preclude substitutes in the drilling mud market. Transportation costs, the availability of cheaper imports, and the growth rate of barite demand affect the development of domestic barite resources. The principal environmental impact of barite mining is the land disturbance normally associated with mining. Barite dust from grinding plants can be controlled satisfactorily by air pollution control equipment.

9. WORLD MINE PRODUCTION AND RESERVE BASE

	Production		Reserve Base*
	1982	1983e	
United States[1]	1,845	700	60,000
Canada	33	25	20,000
Chinae	990	700	20,000
France	220	180	6,000
Germany, Federal Republic of	193	160	6,000
India	359	300	40,000
Ireland	287	200	9,000
Italy	196	170	6,000
Mexico	357	280	10,000
Morocco	461	310	4,000
Peru	400	250	8,000
Thailand	351	300	10,000
U.S.S.R.e	570	550	10,000
Yugoslavia	50	40	3,000
Other Market Economy Countries	1,207	1,000	22,000
Centrally Planned Economiese	368	300	10,000
World Total (may be rounded)	7,900	5,500	244,000

10. WORLD RESOURCES

In the United States, identified resources of barite are estimated to be 100 million tons, and the hypothetical resources include an additional 150 million tons. The world's barite resources in all categories are about 2 billion tons, but only about 400 million tons are identifed.

11. SUBSTITUTES

In the drilling mud market, alternatives to barite include celestite, ilmenite, iron ores, and synthetic hematite manufactured in the Federal Republic of Germany. However, none of these substitutes has had major impact on the barite drilling mud industry.

* Pending establishment of criteria for the reserve base, classification of data is based on a judgmental appraisal of current knowledge and assumptions.

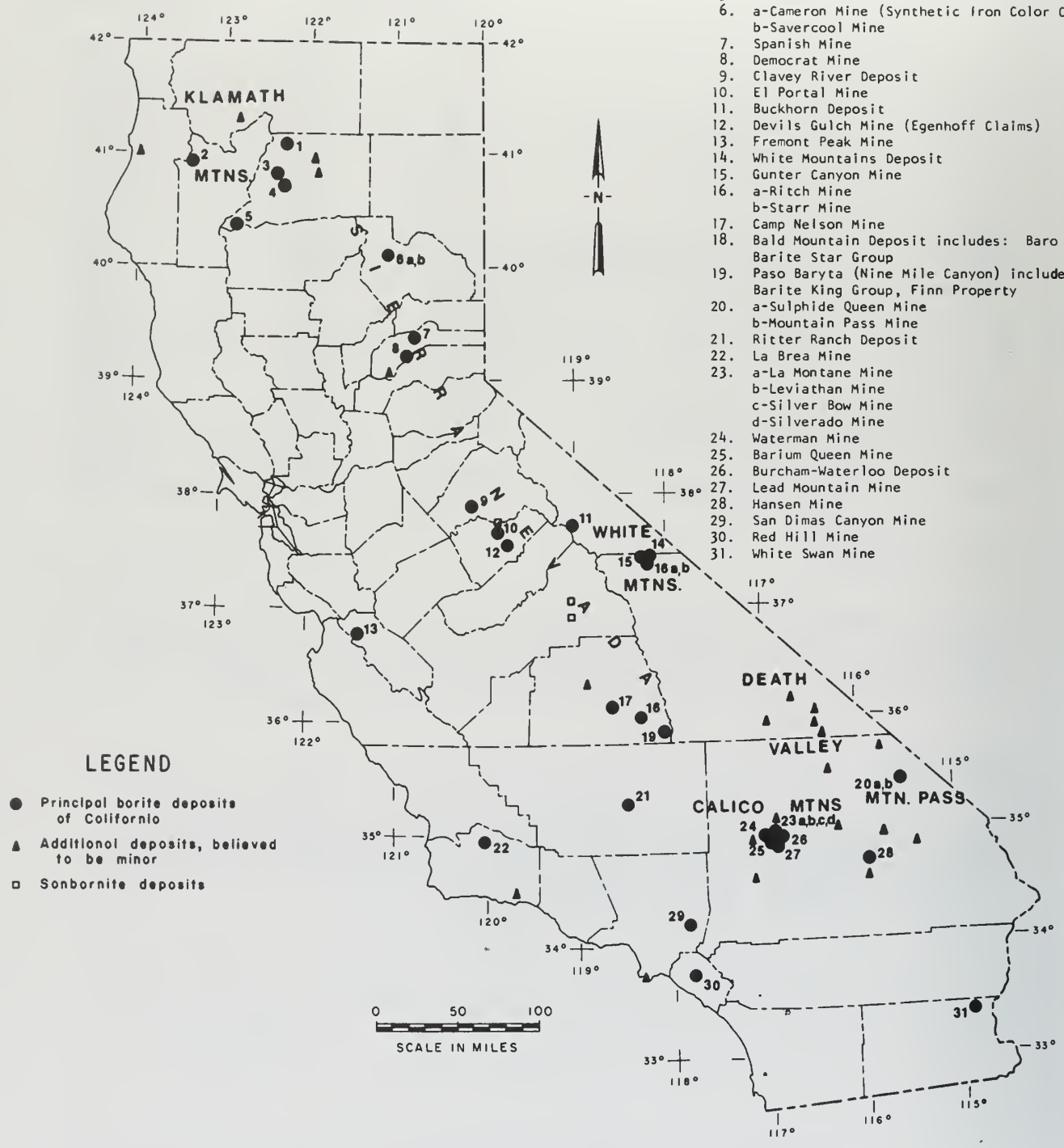

Figure 1 - Barite deposits of California. After Weber, 1963

PART II: CALIFORNIA

12. CALIFORNIA GEOLOGICAL OCCURRENCES

Geological occurrences of barite in California are of three types: (1) veins or fracture-fillings of hydrothermal origin formed at low to moderate temperatures; (2) bedded sedimentary and replacement deposits; and (3) carbonatite deposits associated with potassium-rich igneous rocks. In the United States, bedded deposits and residual deposits derived from pre-existing barite rock are the most commercially important types, while in California, bedded and hydrothermal deposits dominate (Brobst, 1975).

Bedded deposits are commercially important because they contain large tonnages easily beneficiated for use in drilling mud. Beds of barite up to 50 feet thick occur in zones of up to 100 feet extending over many acres. Barite is interbedded with chert, mudstone, shale, siltstone, and bodies of carbonaceous limestone or their metamorphosed equivalents. Barite in these deposits is fetid, usually dark-grey to black, and fine grained. The chief impurity is fine-grained quartz, with small amounts of clay minerals and occasional pyrite present. These deposits are typically Devonian in age (Brobst, 1975). Originally, it was thought that these deposits were formed by replacement of soft sedimentary rocks; however, current theory favors replacement and primary deposition. Bedded deposits are formed by solutions that rise along fissures in the ocean floor and discharge as submarine hot springs. These brines carry barium and react chemically with seawater sulphate to precipitate barite. Replacement occurs in partially closed systems in the upper part of soft marine sediments (Clarke, 1984).

Vein and cavity-filling deposits occur along faults, gashes, joints, bedding planes, and breccia zones. The host rocks are of Precambrian to Tertiary age in the United States. Most of the barite in these deposits is dense, grey to white, and is associated with gold or silver mineralization typical of low-temperature hydrothermal solutions. Recent evidence suggests that some barite and minerals of base metals may form vein deposits from circulating connate and ground waters (Brobst, 1975). Similarly, barite deposits, once thought to be vein or replacement type involving hydrothermal solutions, are now being characterized as sedimentary (Taylor and others, 1984).

The third type of deposit should perhaps be included with the above, but is separated here due to its unique character. This deposit is the massive carbonatite intrusion located near Mountain Pass in San Bernardino County. The carbonate body and associated veins occur in Precambrian metamorphic rocks and are genetically related to nearby potassium-rich intrusive rocks of probable Precambrian age. Barite occurs with calcite, celestite, strontianite, bastnaesite (a rare earth ore) and other accessory minerals (Molycorp, 1980). Although mined by Molycorp for rare earths, the Mountain Pass carbonatite is probably the largest deposit of barite in California. Molycorp does not currently recover and stockpile barite, and has not field tested barite concentrates to determine their suitability for use in drilling mud (Steve Castor, 1984, personal communication).

Sanbornite-bearing rock occurs as tabular lenses or bodies in metamorphosed sedimentary rocks and associated Jurassic plutonic rocks. These deposits are usually small, and form as a result of contact metamorphism of barite-rich sedimentary rocks. The sanbornite is light grey to white, and usually associated with diopside, quartz, pyrite, and other barium minerals. Due to the small size of deposits, Sanbornite has never been mined commercially (Matthews and Alfors, 1962).

13. CALIFORNIA LOCALITIES

Northern Sierra Nevada and Klamath Mountains

Bedded deposits of barite occur in Paleozoic metamorphosed sedimentary rocks of the northern Sierra Nevada and in mildly metamorphosed Devonian sedimentary rocks of the Klamath Mountains. These deposits range from 5 to 30 feet thick and are up to 300 feet long. Typical ore is banded, grey to dark grey and contains 90 to 95 percent barite. Accessory minerals are quartz and pyrite. Major deposits include the Cameron, Democrat, Spanish and Loftus (Glidden) deposits. Although the Spanish and Democrat deposits were initally described as hydrothermal veins, they are now identified as bedded sedimentary deposits (Weber and Matthews, 1967; Paulsen, 1976; Papke, 1983).

Approximately 150,000 tons of barite have been produced from these deposits. One, the Spanish Mine, is still active. Ore from these deposits is dense, specific gravity 4.2-4.5, eliminating the need for beneficiation (Kundert, 1956; Weber, 1963; U.S. Bureau of Mines Statistics). Potential for future mining is greatest at the Democrat Mine, which may contain upwards of a million tons of barite (Paulsen, 1976).

Central Sierra Nevada

Vein deposits of barite occur in northwest- to north-trending belts of phyllite, schist, quartzite, and marble associated with the Mesozoic Calaveras complex of the central Sierra Nevada. Average length of the veins is several hundred feet, with an average width of 3 to 8 feet. The units have a maximum thickness of 40 feet. Veins commonly pinch and swell, and are faulted. The largest and most extensive of the known deposits are the El Portal, Nine Mile, Bald Mountain, and Devils Gulch deposits. These deposits average about 75 to 85 percent white to grey barite, 10 to 20 percent quartz, with calcite, witherite, pyrite, and other minerals. Most of the witherite mined in the United States was produced at the El Portal deposit (Weber, 1963). Sanbornite was first discovered north of El Portal at Trumbull Peak near Incline, Mariposa County. Three small lenses, extending no more than 10 feet, were found in quartzite, part of a series of Paleozoic sedimentary rocks. Contained within the lenses are sanbornite, celsian, diopside, quartz, pyrrhotite, witherite, and taramellite. The largest sanbornite deposit in the world is near Rush Creek, Fresno County. Large bodies of sanbornite-quartz rock occur at, or close to, the contacts of metamorphosed sediments and late Jurassic quartz diorite or completely within the latter. Deposits range in size from one foot diameter bodies to one 200 feet long, 40 feet thick and of undetermined depth. Accessory minerals are diopside, pyrite and the barium

minerals witherite, taramellite and gillespite. A few miles south of Rush Creek, sanbornite occurs as small deposits in quartzite and calc-silicate rocks near Big Creek. (Alfors and Pabst, 1984; Matthews and Alfors, 1962).

Approximately 55 percent of state barite production has come from the El Portal deposit. Less than 100,000 tons have been mined from the Nine Mile Canyon and Almann deposits. Most of the ore mined in this region has been upgraded to 4.2 specific gravity from about 3.9 to 4.1. Outer parts of the veins are less dense than inner parts. Low potential exists for future development of these deposits (Weber, 1963). Sanbornite has never been commercially mined. Although sanbornite is easily dissolved for recovery of barium, low barium chemical demand, low tonnage and distance from markets preclude development at this time.

Calico Mountains and Vicinity, San Bernardino County.

Steeply-dipping veins of barite and barite-jasper are located in volcanic and related pyroclastic and sedimentary rocks of Tertiary age in the central Mojave desert. Composite veins consist of interlayered barite and jasper, or barite, jasper, and country rock. Barite is also associated with minerals of manganese and iron, and deposits of silver. Veins range in size from veinlets to as much as 1,500 feet in length and from 20 to 50 feet wide. Average barite composition of deposits seriously mined or prospected for barite is about 50 to 80 percent (Weber, 1963).

The only significant production was at the Leviathan Mine, San Bernardino County, where 100,000 tons of ore were mined. The ore was upgraded from a specific gravity of 4.2 from 3.6 to 3.9. The barite is characterized by a high iron content. The principal undeveloped deposit is ASARCO's Waterloo Mine, located near Calico (Henderson, 1980; Weber, 1963).

White Mountains, Inyo and Mono County

Discontinuous veins and small bedded deposits are found in diabase, shale, sandstone, and marble of Cambrian and Precambrian age. Vein deposits are usually associated with base metal sulfide mineralization. Thickness ranges from 2 to 8 feet as the deposits pinch and swell along strike. Total output, principally from Gunter Canyon was small, totalling less than 5,000 tons. The irregularity and thinness of known deposits, combined with the distance from markets, limits this area as a source of barite (Weber, 1963).

Mountain Pass area, San Bernardino County.

A large carbonatite body and associated veins intrude a sequence of Precambrian metamorphic rocks. The main carbonate intrusion is about 2,300 feet long and ranges from 100 to over 200 feet wide. Drill hole data indicates the ore body is at least 3,000 feet deep. The rock is composed of 40 percent calcite, 25 percent barite and/or celestite, 10 percent strontianite, 12 percent bastnaesite (rare earth ore) and 8 percent silica. Accessory minerals are apatite, galena, hematite and monazite (Worhol, 1980). The barite is contaminated with small amounts of strontium, iron, phosphorus, bastnaesite, monazite and thorium minerals. The latter three impurities are mildly radioactive, and may interfere with

radiometric drill hole logging, which would make the barite unuseable for drilling mud. Laboratory testing at Molycorp indicates radiation levels are too low to interfere with radiometric logging, but Mountain Pass barite has never been used in drilling mud. If eventually proven inert and suitable for making mud, potential barite production at Mountain Pass is over 40,000 tons a year (Steve Castor, 1984, personal communication).

Southern Coastal Region

The deposits of this region are characterized by irregular vein deposits in Franciscan and Tertiary rocks. The Red Hill deposit contains barite associated with mercury mineralization. Production from this district totals less than 10,000 tons almost wholly from LaBrea Canyon. Small amounts were recovered as byproduct from mercury mining at Red Hill. Additional ore may be present at LaBrea Canyon. Other deposits are too irregular to be economical at this time (Weber, 1963).

Blythe Region, Riverside and Imperial Counties

Barite occurs with manganese and other minerals in veins intruding various Tertiary and older rocks. The White Swan deposit consists of veins of nearly pure barite with manganese minerals and jasper, that range in width from 2 to 4 feet. Minor production was reported from the White Swan deposit. In general, deposits of this area are thin, making it difficult to mine large tonnages of high quality material.

Death Valley region, Inyo and San Bernardino Counties

Thin veins of barite are present in principally Precambrian metamorphic rocks. These deposits are small and remain unmined. Little potential exists for future commercial exploration.

Foothill belt and Shasta region

Barite occurs as a gangue mineral with copper, zinc, and other minerals in sulfide replacement bodies associated with shear zones in metavolcanic rock of pre-Cretaceous age. There has been no reported barite production and future commercial development seems unlikely.

14. CALIFORNIA PRODUCTION

The barite deposit near El Portal, Mariposa County is reported to have been first mined in the 1880s, but production records only date back to 1910. Total historic production of barite in California is approximately 950,000 tons. From 1976 to 1980, no barite was mined in California, and prior to 1976, the only significant production was from the Glidden Company deposit in Shasta County (U.S. Bureau of Mines Mineral production statistics). From June 1980 to October 1982, 71,418 tons of barite were mined at the Spanish Mine in Nevada County. The mine was not worked in 1983. The new lease holder, Geo Drilling Fluids, plans to remove 100,000 tons of barite in 1984, and will complete mining in 1985 if necessary (Ostler's Rocky Mountain Refractories, 1984, personal communication).

15. UTILIZATION AND MARKETS

Most barite mined in California since the late 1920s has been used as a weighting agent for fluids circulated in rotary drilling of oil, gas and water wells. This mud, a mixture of water, clay, and barite, helps cool the drill bit, remove rock cuttings, lubricate the drill rods, seal the walls of the hole, and by its weight, helps to confine high oil and gas pressures, assisting in the prevention of blowouts or gushers. Depending upon the number of oil and gas wells being drilled, barite crushed for drilling mud comprises 80 to 90 percent of barite consumed in the United States. Mud-grade barite must have a minimum specific gravity of 4.2 (about 93 percent barite). Barium chemicals derived from barite are found in thousands of products and industrial processes ranging from ceramics, metals, and paint to medicine and vitamins, and sugar manufacturing (Brobst, 1975; Weber and Matthews, 1967).

An integral part of the barite industry involves crushing. Currently, barite is crushed at two mills in California. One mill is located in the town of Laws, near Bishop. The mill is owned and operated by Standard Industrial Minerals and processes approximately 4,900 tons of barite a year. The product is used to manufacture the foam in carpet pads and as a filler in heavy grey and primer paint. The second mill is located in Sacramento, and is owned by Industrial Minerals Company. All raw material crushed and processed at the Laws plant is mined in Nevada. The Sacramento mill also crushes barite from Nevada, but 65 percent of its raw material comes from the Spanish Mine in Nevada County. Ore from the Spanish Mine has a specific gravity of 4.4 and is mixed with lower-grade Nevada ore to make 4.2 gravity drilling mud. The Sacramento mill currently averages 12 to 15 thousand tons of barite a year, which is about half the plant capacity of 25 to 30 thousand tons. All barite currently processed is sold to mud companies. Demand for barite is dependent on local drilling activity (Archie Wood, 1984, personal communication, Ken Rekstad, 1984, personal communication).

16. MINING METHODS AND BENEFICIATION

The relative softness of barite allows the ore to be mined with earthmoving equipment. Ore at the Spanish Mine is ripped by bulldozer, then hauled by scapers and front end loaders to the stockpile. Broken ore, usually less than 24 inch blocks, is reduced by a small jaw crusher at the mine to 1 inch minus. The barite product is then trucked from the mine, located north of Nevada City, to the mill in Sacramento. The material is mixed with Nevada barite to adjust grade, crushed to minus 325 mesh, and bagged or shipped bulk to mud service companies (Roy Winder, 1984, personal communication).

17. CALIFORNIA EVENTS, TRENDS, AND ISSUES

United States production of barite is tied to domestic oil and gas well drilling activity. The federal government decontrolled oil in early 1981, resulting in a large increase in exploration (many new wells drilled) and

record production of barite. Although California experienced a similar boom in drilling activity, less than 5 percent of all oil and gas wells drilled domestically are in the state (Clarke, 1984; Papke, 1983).

Increasing barite prices allowed resumption of mining at the Spanish Mine in Nevada County in 1980. The mine has operated intermittantly since 1980, remaining idle in 1983 due to the economy. Mining will continue through 1985 if leased reserves are not extracted this year. Only 20,000 tons a year are scheduled to be trucked to Sacramento for milling, with the remainder to be stockpiled at the mine site. Unstable pit slopes and restricted surface area make mining difficult, and preclude the economic extraction of tons of remaining barite. The Spanish Mine is scheduled for reclamation upon termination of the current mining activity (Roy Winder, 1984, personal communication).

To comprehend California's role in the domestic barite market, it is important to review the market's recent trends. The domestic barite market has declined sharply since 1981, due to decreased oil and gas drilling and foreign competition. In the United States, over 80 percent of oil and gas wells are drilled in areas closer to gulf coast ports than western production areas. Rail freight haulage fees add $36 to $40 a ton to the mine price of $35 per ton of barite delivered to gulf coast (Texas, Louisiana) grinding plants. Barite mined overseas is delivered to the same ports at prices up to one-third lower than domestic barite. These low prices are the result of reduced mining costs, depressed ocean freight rates, $13 a ton from China, and low import duties. Thus, imports now account for over 60 percent of U.S. barite consumption, which itself has declined more than 50 percent since 1981. As a result, domestic barite production has dropped 75 percent since 1981. Foreign imports of barium chemicals are a major factor in the early 1984 closure of FMC's barium chemical manufacturing plant in Modesto. This plant accounted for about two-thirds of domestic production capacity. The only operating domestic plant is located in Georgia, precluding the possible use of California barite for American made chemicals. California also cannot compete in the domestic drilling mud market because of prohibitive transportation costs (Papke, 1983; Clarke, 1984; Griffiths, 1984).

Nevada produces 90 percent of the barite mined in the United States. Many mines there have closed during the last three years. Although barite mined in Nevada is used in California, barite from the Spanish Mine can be economically mined because of its high specific gravity which eliminates the need for expensive beneficiation of ore. The Spanish Mine is also located closer to local markets. Barite prices have declined 40 percent since 1981, whereas rail freight costs have only dropped slightly. Thus, transportation charges comprise a greater percentage of the total price for Nevada barite shipped by rail to California, which allows the local product, trucked to the mill, to compete even though mining costs are higher (Clarke, 1984; Ken Rekstad, 1984, personal communication).

The California barite industry is directly related to west coast petroleum exploration activity. The average growh rate for the domestic barite industry from 1983 to 1990 is projected at 4 percent. If reflected in California, higher barite prices could allow small operations, like the

Spanish Mine, to continue mining. Alternatively, by-product barite from Mountain Pass or ASARCO's currently undeveloped Waterloo silver property could monopolize the local barite market, similarly, foreign producers, who have ignored the small west coast market, could also monopolize the market by delivering low priced barite to western ports (Papke, 1983; Clarke, 1984; David Tunison, 1984, personal communication).

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IMMEDIATE RECALL

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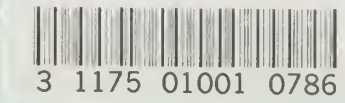
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